

Next Generation Life Support (NGLS): High Performance EVA Glove (HPEG) Technology Development Element

Game Changing Development Program | Space Technology Mission Directorate (STMD)



ABSTRACT

The overall objective is to develop advanced gloves for extra vehicular activity (EVA) for future human space exploration missions and generate corresponding standards by which progress may be quantitatively assessed. The glove prototypes that result from the successful completion of this technology development activity will be delivered to NASA's Human Exploration Operations Mission Directorate (HEOMD) and ultimately to be included in an integrated test with the next generation spacesuit currently under development.

ANTICIPATED BENEFITS

To NASA funded missions:

Ultimately the first "mission use" will be integration with advanced space suits under development by NASA's Advanced Exploration Systems Program.

Although not an official "customer", the International Space Station could benefit from this technology if its operational life is extended. New gloves developed by HPEG could be evaluated and eventually used on the International Space Station.

To NASA unfunded & planned missions:

HPEG gloves are an enabling technology. They are under development to meet requirements for a broad set of future exploration missions & advanced spacesuits under development by NASA.

Proving Ground - such as for use integrated with space suits used during a possible asteroid redirect mission or return missions to the Moon.

Earth Independent - such as deep space including human missions to Mars, both the transit and surface phases.



High Performance EVA Glove

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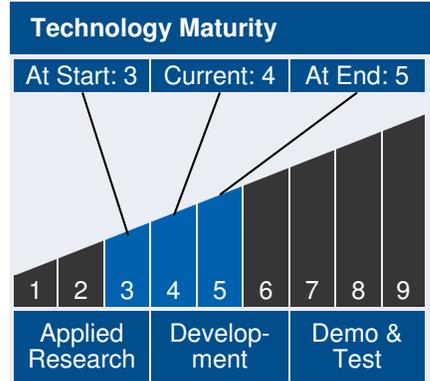
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DETAILED DESCRIPTION

Requirements for EVA for exploration missions will significantly differ from the International Space Station (ISS). Whereas the ISS external environment is relatively pristine, dust and other foreign debris on all exploration missions can easily migrate through protective glove outer layers creating a high potential for loss of hardware and an increased risk to crew. Furthermore, EVA frequency on ISS is less than 24 hours per quarter, whereas for exploration missions we anticipate the frequency as high as 24 hrs of EVA per week. Given the availability of regular resupply to ISS, durability becomes less of a concern because gloves can be replaced after 7 EVAs. However, resupply is not an option for long duration exploration missions and the necessary spares to keep the same paradigm is prohibitive from a launch mass perspective (~6.25 lbs per pair).

The state-of-the-art (SOA) gloves used on the ISS space suit are an aging technology. These gloves, identified as "Phase VI gloves", have been modified in minor ways in response to specific failures during the 18 years since their first deployment. More radical updates have not been made due to the high cost of larger scale changes. For example, in the early 2000s, there were several instances of glove damage with cuts completely through the protective outer layers of the palm. The response was to add thick cut-resistant materials to the thumb and palm regions. This change resolved the cut glove issue but the glove was noticeably more difficult to flex. In keeping with the trend to only make minor changes, the response to hand injury has been to order more custom glove sizes for EVA crew members, rather than to make radical changes to improve flexibility. Even with 61 sizes of gloves in inventory, with finger adjustments of 0.5 in for each finger, new custom gloves are being fabricated at an average of 2 per year to meet crew needs



Realized Benefits

3 Conference Papers

Management Team

Program Executive:

- Ryan Stephan

Program Manager:

- Stephen Gaddis

Project Manager:

- Daniel Barta

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and yet injuries still occur regularly to crew in training and on orbit.

The HPEG Project Element believes the issues of mobility, fit, and durability must be addressed in a systemic manner that incorporates new technologies and manufacturing techniques to meet the performance challenges of exploration missions. Specific quantitative objectives for high performance EVA gloves include:

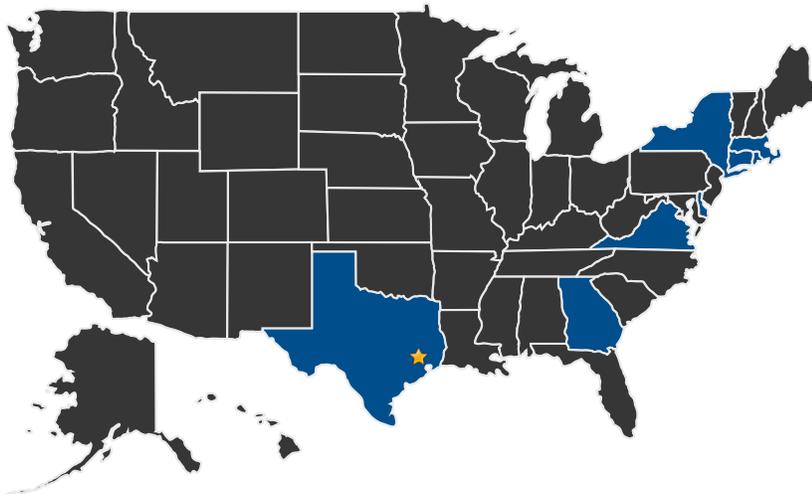
1. Enable hand mobility comparable to 60% of bare handed capability when wearing the complete glove assembly pressurized to 4.3 psid.
2. Maintain structural integrity after completion of cycle testing in non-pristine environment for the equivalent of 50 EVAs.

Technology Areas

Human Health, Life Support, and Habitation Systems (TA 6)

- Human Exploration Destination Systems (TA 7)

U.S. LOCATIONS WORKING ON THIS ELEMENT



■ U.S. States
With Work

★ **Lead Center:**
Johnson Space Center

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Contributing Partners:

- Air-Lock
- Aspen Aerogels, Inc.
- David Clark Company Inc.
- Final Frontier Design
- ILC Dover
- Nanosonic, Inc.
- nGimat Co.

ELEMENT LIBRARY

Conference Papers

- Feasibility Assessment of an Extravehicular Activity Glove Sensing Platform to Evaluate Potential Hand Injury Risk Factors
 - (<https://techport.nasa.gov:443/file/17415>)
- Monitoring Human Performance during Suited Operations: A Technology Feasibility Study Using EVA Mobility Unit Gloves
 - (<https://techport.nasa.gov:443/file/17413>)
- Spacesuit Glove-Induced Hand Trauma and Analysis of Potentially Related Risk Variables
 - (<https://techport.nasa.gov:443/file/17423>)

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IMAGE GALLERY



*Test Subject in Pressurized Suit
Performing Pin Tasks*



*Robotic assist gloves are under
development to provide mechanical
assist astronauts as they conduct
physically intensive tasks and should
reduce fatigue by allowing the
astronaut to relax their hand while the
glove maintains a gripped position.*



*Evaluation of the robotic assist glove
sensors using a dynamometer to
measure grip force.*

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First suited testing of the sensor gloves. Laboratory testing of the sensor gloves provided feedback on the test subject's mobility and comfort using the gloves and allows for a preliminary assessment of sensor performance prior to operational use.

The sensor glove is worn underneath space suit gloves during glove testing. The intention is to gather data such as temperature, force, and humidity levels to help determine causes of hand injuries that are seen to occur during suited operations.

DETAILS FOR TECHNOLOGY 1

Technology Title

High Performance EVA Gloves (HPEG)

Technology Description

This technology is categorized as a hardware component or part for wearable applications

The overall project objective is to develop advanced EVA gloves for future human space exploration missions and generate corresponding standards by which progress may be quantitatively assessed. Glove prototypes will be delivered to HEOMD and included in an integrated test with the next generation spacesuit currently under development.

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Capabilities Provided

The aim of technology development is to provide potential glove vendors with metrics for emerging technologies that show promise for improving glove performance with respect to mobility, durability, and comfort and which build upon previous NASA experience and technology investments. It is our goal that this knowledge will reduce both cost and schedule for the overall integrated glove prototype development activity. Technology focus areas include flexible aerogel, dust management, in-glove sensors, and robotic grip assist.

Potential Applications

There are three potential applications for the high performance EVA gloves within NASA. The gloves could be potential replacements for the Phase VI gloves in current use on the ISS. The gloves could potentially be used with a modified version of the Advanced Crew Escape Suit (ACES) used on the Space Shuttle, for potential use for Asteroid Retrieval Missions. Finally, the gloves are planned for integration within a new advanced space suit under development by the Advanced Exploration Systems (AES) Advanced Space Suit Project. It is our expectation that the new gloves, at a technology readiness level of 5 (TRL 5) will be available to support thermal vacuum chamber testing with the Z-3 suit in 2018. HPEG will provide AES with all appropriate documentation for sizing gloves for use with Z-3 and for conducting evaluations in the 100% oxygen environment.

The HPEG Project Element is also teaming with NASA's Human Research Program (HRP) to buy down "Risk of Compromised EVA Performance and Crew Health Due to Inadequate EVA Suit Systems." The HPEG Project Element supported an activity to perform statistical analysis of injuries reported to date to identify correlations and causation for hand injury and to investigate new methods to assess injury potential of gloves early in their design and/or life cycle. The results of this joint effort will be published to the HRP risk system to formally address and reduce the risk as appropriate.

Performance Metrics

Metric	Unit	Quantity
Hand mobility comparable to bare hand when pressurized to 4.3 psid	%	60

Continued on following page.

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Performance Metrics (cont.)

Metric	Unit	Quantity
Duration before loss of structural integrity when used in non-pristine environment	Cycles	50